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## FINAL TECHNICAL REPORT

NASA Grant Number NAG5 - 1459

Project Title Cataloguing of AAVSO Optical Data  
for NASA Master Directory and IUE

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## Scientific Objectives of the Proposed Project

The objective of this project is to prepare two catalogues essential as research aids in multiwavelength investigations of satellite data on variable stars. The first catalogue will contain information on available AAVSO optical data on about 3000 variable stars in its observing program, the time span of the data, and the coverage. The second catalogue will contain approximately 800,000 observations from 1978 to 1988 on 75 variable stars observed with the International Ultraviolet Explorer (IUE).

The American Association of Variable Star Observers (AAVSO) has the largest data base on optical observations of variable stars beginning with the founding of the organization in 1911. In the last two decades AAVSO observations were utilized extensively in space research on variable stars using NASA spacecraft. The AAVSO provided data on request to individual investigators observing with the spacecraft. NASA's Astrophysical Data Systems (ADS) contains information on multiwavelength observations of variable stars observed with various spacecraft. The two catalogues prepared by the AAVSO will be placed in ADS and other data centers to enable researchers in data correlation, data analysis, and in scheduling ground-based and satellite observations.

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## Technical Description of the Project and the Results

Phase Ia : Preparation of a general catalogue for the ADS describing the AAVSO data base and data archives.

To prepare the general catalogue for the ADS on AAVSO data, AAVSO technical staff inspected data files and handplotted light curves of each of the stars in the AAVSO observing program. We selected 2600 stars for this catalogue out of a possible 3000. The other 400 either had only very few observations over decades, or else were stars suspected of variability but not confirmed. We determined the time when AAVSO observations were begun, and also graded the observing coverage on each of the 2600 variable stars. We also included in this general catalogue information on which of the 75 stars in the second catalogue have been observed by satellite: not only with the IUE but also with High Energy Astronomical Observatory - 2 (Einstein), and the European X-ray Satellite (EXOSAT).

The AAVSO obtained a magnetic tape of the Fourth edition of the *General Catalogue of Variable Stars* (GCVS) from the NASA Astronomical Data Center at Goddard Space Flight Center. We extracted information on the 2600 project stars from this tape using Digital

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MicroVax computer systems at the Harvard-Smithsonian Center For Astrophysics (CFA). We then incorporated this information with the tables obtained on AAVSO data. In preparing this catalogue we spent a significant amount of time in checking the magnitude range information of each of the stars. Quite often the information in the third edition of the *GCVS* was different from that in the fourth edition. Whenever we found such differences, we used the more appropriate value from either edition of the catalogue. On long period variable stars, we used the mean magnitude ranges given in the third edition of the *GCVS*.

Finally we consulted with Dr. Steve Murray, in charge of ADS at CFA, for the required format for the ADS, and made the appropriate format changes. We placed the catalogue in ADS in 1991. We also prepared a hard copy version of the catalogue which is now being distributed, upon request, to the astronomical community.

Phase Ib: Expansion of AAVSO computer hardware and software capabilities.

One of the objectives of this project was to expand the computer hardware and software capabilities of the AAVSO so that Phase II of the project -- preparation of a catalogue of optical data files on 75 variable stars -- could be accomplished. Phase Ib was accomplished in the following way:

Expansion of hardware capabilities: One 80x86-based workstation with a VGA monitor, and a 120 MByte cartridge tape drive was installed. This system designated as the "host" system, is rated 50 MHz with 8 MByte of memory, an 80487 math co-processor, two 300 MByte hard disks, and a ZOOM modem V32 (9600 baud). The host communicates with all the other in-house computers via ALLOY network software.

Expansion of software capabilities: Computer programs to archive and access large volumes of data and data files were developed by a computer specialist. Further computer programs were developed to graph large volumes of data over a long time interval, both on screen and on paper, and to have interactive evaluation capability of each of the data points. All of these programs were essential for Phase II of the project.

Phase II: Preparation of a catalogue of optical data files on 75 mostly cataclysmic variable stars observed with IUE.

We began the Phase II of this project by transporting to the host system at AAVSO headquarters the 4.5 million observations of variable stars from 1963 to date that were stored on magnetic tapes at CFA. We then obtained from the IUE Center at NASA Goddard Space Flight Center a list of all the variable stars observed with the IUE, identified those variable stars that are in the AAVSO observing program, and then checked the coverage of these stars in the AAVSO database. We then identified the 75 variable stars observed with IUE. Initially, these stars were all supposed to be cataclysmic variables; however, there was an inadequate number of cataclysmic variables observed with the IUE having sufficient AAVSO coverage. Therefore, we added other (sympiotic and long period) types of variable stars observed with IUE to make up the 75 data files.

A significant number of these stars were also observed with other satellites. Thus, we obtained and checked the Observing Logs of the High Energy Astronomical Observatory 2 (Einstein) and the European X-ray Observatory satellite (EXOSAT), and identified the stars observed with each of these satellites. These were also indicated in the first catalogue prepared for the ADS.

Once we identified the 75 stars, we began the evaluation of each of the data points in the 10 years of data of each star. While evaluating data in the AAVSO archives for one of these stars, we discovered that some observations were missing from the more recent AAVSO data archives. Investigation revealed a defective hard disk on one of the in-house microcomputers systems which allowed random records to be lost without appropriate error messages being reported. The defective disk had been in use for approximately two years before the problem was discovered; it affected the 1988 data files, which are part of the data set for the IUE catalogue.

We replaced the hard disk. A thorough examination of all data computerized during the time the defective disk had been in use (approximately 550,000 observations) revealed which observations had been lost. They were restored to the archives. During the course of this detailed examination of the computer archives, we developed a significant number of programs to provide a system of checks and balances which ensures that no data are being lost or corrupted in the data processing or archiving procedures. These programs help to ensure the integrity of the AAVSO computer archives. Once the lost observations were added back to the archives we continued with evaluation of the data for the 75 stars.

The AAVSO Director (Principal Investigator of the project) and technical staff are closely evaluating AAVSO observations for accuracy and quality for the interval 1978 to 1988 for each of the 75 stars. The computer programs we developed are essential to the evaluation process. However, we find that a much longer time than that allocated in the proposal is necessary due to the extent of the data and the thoroughness needed for the evaluation of each star. As the evaluation of a star's data is completed, the observations are extracted from the AAVSO data archives for addition to the ADS and other data centers.

At this time, we have evaluated the data on 35 stars; these data will soon be placed in the ADS. The evaluation of the remaining 35 stars continues, and the data will be placed in the ADS as soon as the evaluation is completed. This work is accomplished without any additional charge to the grant.

### Publications and Data Exhibits

The following were published on this project:

Mattei, J. A. 1992, "The AAVSO and Its Variable Star Databank", *Astronomy From Large databases II*, Ed. A. Heck, F. Murtagh, *ESO Conference and Workshop Proceedings*, No. 43, 367.

Mattei, J. A. 1991, *Journ. American Assoc. Variable Star Observers*, 20, 257.

Mattei, J. A. 1990, *Journ. American Assoc. Variable Star Observers*, 19, 168.

AAVSO Exhibit of its Databank at the American Astronomical Society's (AAS) Meeting, Philadelphia, PA, 1991

Thanks to this grant we were able to set up an interactive exhibit at the AAS meeting in Philadelphia to demonstrate our expanded computer capabilities. The exhibit featured information on the AAVSO and its data accessibility, and described the two catalogs prepared under this grant. This exhibit was very well received by the astronomical community. Since the display we have received a record number of requests (190 per year) for AAVSO data.

We very much appreciate this award and acknowledge it with gratitude. This award enabled us to expand our computer capabilities and expertise. This makes our data processing, archiving, evaluation, and accessing more efficient so that we can meet the objectives of this project with greater facility and provide the astronomical community with quality results.

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Date

Respectfully submitted

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